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METHODS OF MANUFACTURING POTATO CHIPS.

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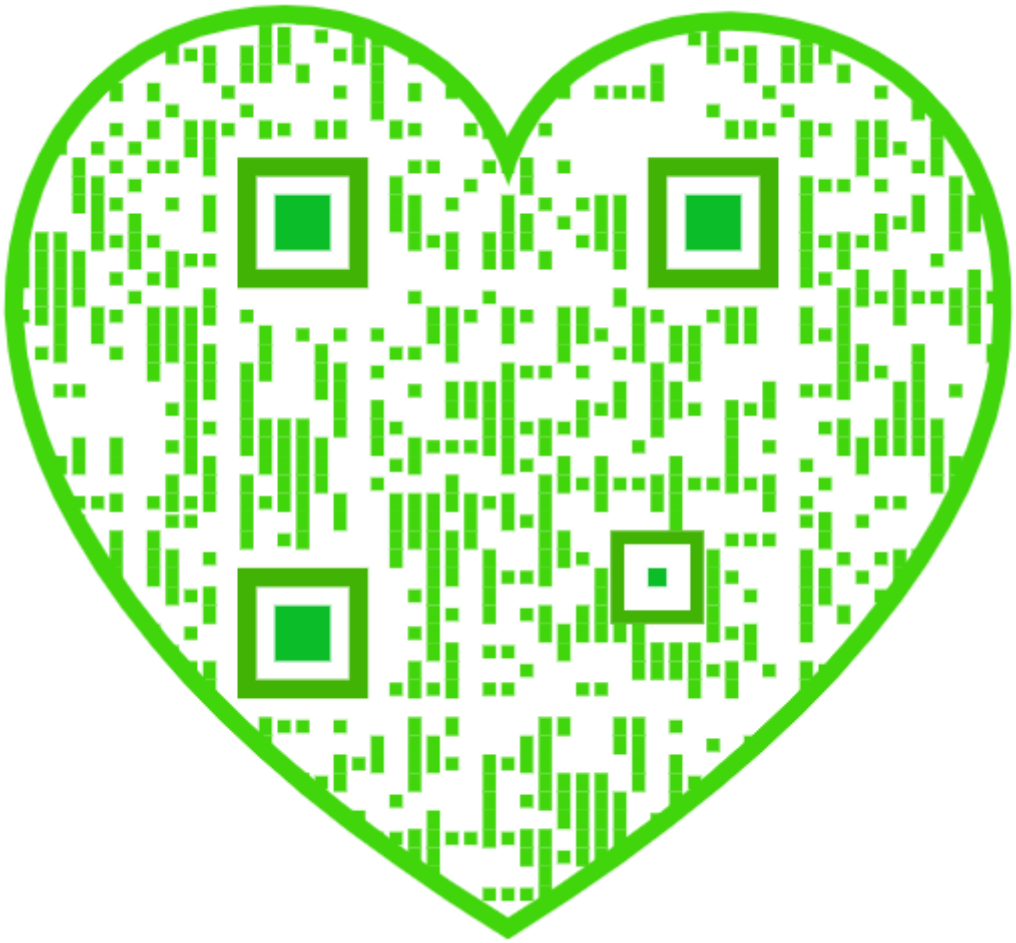
INTRODUCTION.

Potatoes are a universal food and share honors with bread as the "staff of life." There is only one style, however, in which cooked potatoes are now distributed in commercial quantities over long distances in a condition to keep for a considerable time. Crisp, golden potato chips command a ready market in all seasons, and there are firms which supply markets a thousand miles away. Moreover, it is not difficult to prepare them at home with ordinary household equipment if a few fundamental rules are observed.

Beginning in 1914, there has been conducted each winter a series of cooking experiments designed to test the culinary value of a large number of the most promising of the seedling tubers developed in the potato-breeding project of the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry, United States Department of Agriculture. During the first three years a special study was made of methods of making potato chips and the value of the different seedlings for that purpose.

The first year's work, 1914–15, was largely experimental, methods of procedure being developed and standardized. The tests were continued and amplified during 1915–16 and 1916–17. No effort was



made to study commercial varieties systematically, but a number of the varieties from the departmental collection were tested during the course of the three years. These included several varieties from each of Stuart's [1] eleven groups or families. All of these potatoes were grown by the Office of Horticultural and Pomological Investigations on the State Experimental Farm at Presque Isle, Aroostook County, Me. Cultural and weather conditions varied somewhat during the seasons, but the comparison between different varieties is substantially correct, especially between tubers grown in any one year. The potatoes were shipped to Washington each fall and kept in cold storage at the Arlington Experimental Farm until needed. The general results obtained in the cooking tests have been summarized and are presented here.

EXPERIMENTAL METHODS OF MAKING POTATO CHIPS.

In starting these tests it was first of all important to determine the best methods of making chips, the most satisfactory frying medium, and the most efficient equipment to use. The Green Mountain variety of potato was taken as the standard of comparison. The methods employed naturally had to be those adapted to home rather than to commercial usage, because of laboratory limitations in equipment and supplies; but it was intended to make the tests comply with commercial practices in so far as it was possible.

The following recipe for potato chips by Farmer [2] was used as a basis for the investigation:

> Wash and pare potatoes. Slice thinly (using a vegetable slicer) into a bowl of cold water. Let stand two hours, changing water twice. Drain, plunge in a kettle of boiling water, and boil one minute. Drain again and cover with cold water. Take from water and dry between towels. Fry in deep fat until light brown, keeping in motion with a skimmer. Drain on brown paper and sprinkle with salt.

The partial cooking in boiling water was supposed to keep the potato from absorbing much of the fat in which it was fried, resulting in a less greasy product and was, of course, a slightly more economical one, as less grease was consumed. The recipe was followed, with variations, during the preliminary work in 1914–15. Though good chips were secured, the method was not found to be entirely satisfactory, as it entailed too much labor. A study of the methods in use in commercial plants demonstrated that the hot-water bath was neither practicable nor necessary. The problem was to produce

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[1] Stuart, William. Group classification and varietal descriptions of some American potatoes. U. S. Dept. Agr. Bul. 176, 56 p., 19 pl. 1915.

[2] Farmer, Fannie Merritt. The Boston Cooking-School Cook Book . . . p. 314. Boston, 1917.

first-class chips by methods as simple as possible, equally applicable at home or in a factory. The following methods were tried:

(1) Following the recipe given above.
(2) Washing in cold water, which was then shaken off; not dried.
(3) Washing in cold water; dipping in hot water; not dried.
(4) Washing in cold water; dried between towels.
(5) Washing in cold water, dipping in hot and again in cold water; not dried.
(6) Washing in cold salt water and then in clear, cold running water; dipping in hot water; then in cold water and dried.
(7) Soaking in cold water for 24 hours; dipping in hot water; again in cold water; dried.
(8) Not washed or dried; fried as soon as sliced.
(9) Not washed; dried before frying.
(10) Dipping in hot water immediately after slicing; then in cold; drained but not dried.

Some of these methods produced good chips. Certain others, notably Nos. 8, 9, and 10, resulted in a distinctly poor product, soggy and uneven. There was no apparent advantage from the use of the salt-water bath in No. 6. Nor was it found that the hot-water bath was at all essential to producing crisp, nongreasy, high-grade chips. Cutting the potatoes into thin, even slices with an accurate vegetable slicer, soaking them thoroughly in clear, cold water after an initial bath of cold running water, and frying them in a clean, high-grade fat at a high temperature were found to be the three essentials in producing crisp, high-quality chips.

FATS USED IN THE EXPERIMENTAL WORK.

Deep-fat frying to the minds of many housekeepers means frying in lard, and many cookbook recipes for potato chips specify the use of lard. Pure leaf lard, therefore, headed the list of fats which were experimented with. Then came various lardlike derivatives of cottonseed oil, half a dozen standard brands of cottonseed oil, several samples of peanut oil, coconut oil, and a mixture of lard and beef suet.

The most satisfactory frying medium was found to be a high-grade cottonseed oil, and this was adopted as the standard in subsequent cooking tests. Good cottonseed oil was clear and bland and practically flavorless. It proved to be the most economical fat, both because of a lower initial cost and a minimum of waste in cooking; and a comparison of chips fried in the different fats demonstrated its superiority in behavior during cooking and in the flavor of the finished product. Both the lard and the lard and suet mixture imparted a flavor or aftertaste that was unpleasant to some people and left a cloudy coating on the chips that made them less attractive than the clear yellow-brown gloss of chips fried in oil. All the vege-

table oils and compounds were more satisfactory than the animal fats. The liquids were preferred to the semiplastic compounds, being more convenient to use in quantities, less expensive, and less wasteful in utilization.

Most manufacturers of commercial potato chips use cottonseed oil, a few use lard, and a few have experimented with coconut and corn oils. Peanut oil is not yet widely known and has been so far little used in the manufacture of potato chips, but there is no reason why satisfactory results should not be obtained if a highly refined, bland oil is put on the market at prices that will compete with the cottonseed oil now in use.

The smoking point of well-refined cottonseed oil is higher than that of most of the other frying mediums, a much more important factor

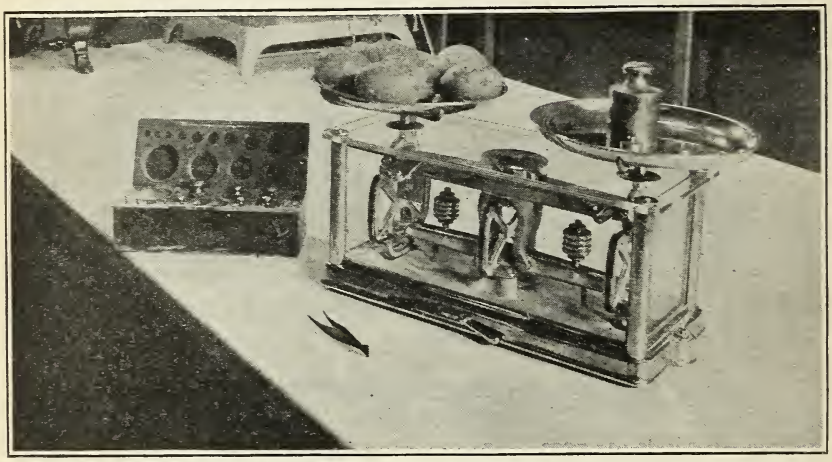

FIG. 1.—First step in making potato chips. Weighing six medium-sized potatoes on a torsion balance.

in frying potato chips than in frying doughnuts, fritters, or similar foods that must be cooked through as well as browned. Blunt and Feeney [3] have determined the burning point of a number of the cooking fats, and their investigations show that cottonseed oil has the highest burning point, 451° F. (232.7° C.), with two cottonseed oil derivatives very nearly the same, 450° F. (232.2° C.), and 448° F. (231.1° C.). Leaf lard smoked at 430° F. (221.1° C.), bulk lard at 381° F. (194.0° C.); olive oil at 347° F. (172.7° C.); two samples of peanut oil at 323° F. (161.6° C.) and 300° F. (148.8° C.), respectively; and coconut oil at 277° F. (136.1° C.).

Some of the samples of peanut oil used in these investigations were almost as highly refined as the cottonseed oil and had as high a smoking point, but others smoked at approximately as low a temperature

[3] Blunt, Catharine, and Feeney, Clara M. The smoking temperature of edible fats. In Jour. Home Econ., v. 7, No. 10, pp. 535–541. 1915.

as the two samples used by Blunt and Feeney. The coconut oil used in the chip experiments of the United States Department of Agriculture smoked at a temperature of 338° F. (170° C.), higher than the

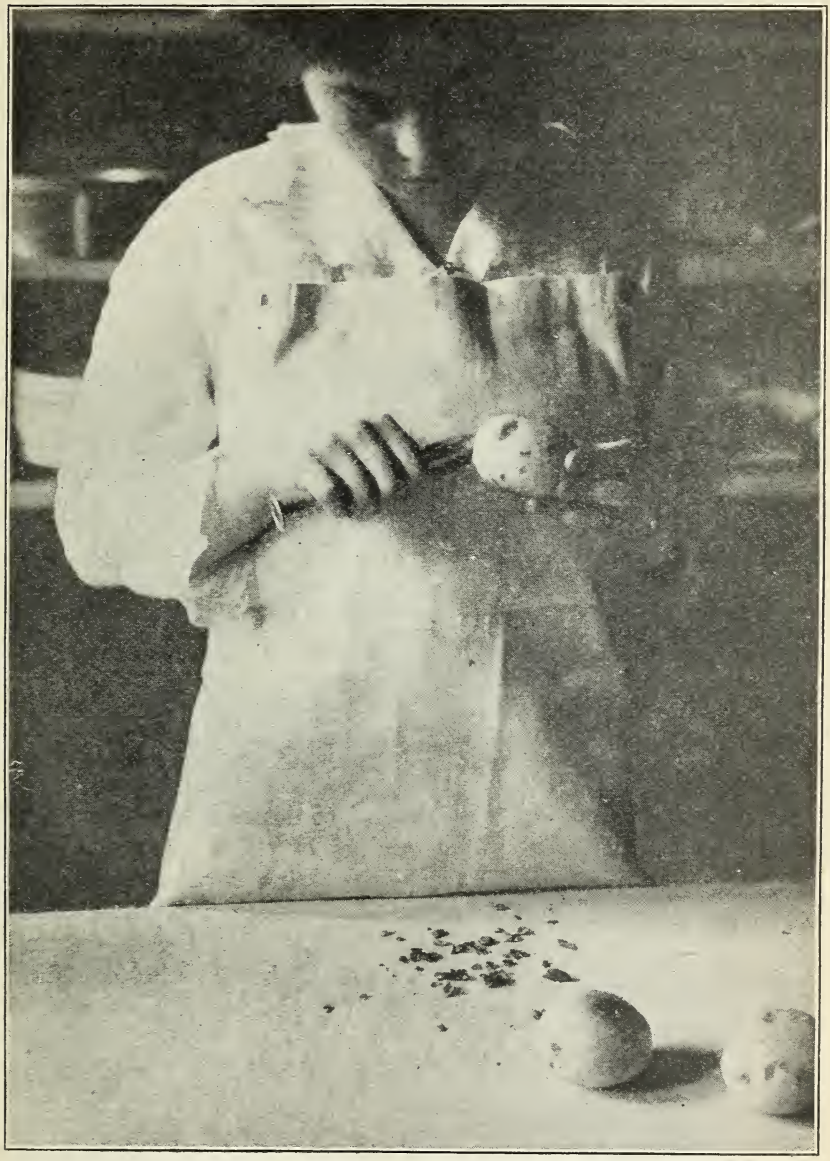

FIG. 2.—Removing eyes and diseased spots from peeled potatoes.

figures given by Blunt and Feeney, but still too low for satisfactory results. Olive oil was not tried; its expense prohibits its use as a commercial frying medium. According to Blunt and Feeney, however,

its smoking point is too low to make it a competitor of the cheaper oils. No fat with a smoking point of less than 220° C. (428° F.) is desirable for frying potato chips. Overheated fat is unwholesome and imparts a scorched flavor to the food.

STANDARD METHOD OF MAKING CHIPS FOR THE TESTS.

As a result of the first year's experiments, the following uniform method of procedure was developed and used as a standard:

Six or seven medium-sized potatoes, with a total weight of approximately 1,000 grams, were first weighed on a torsion balance (fig. 1), then peeled in a vegetable peeler, all eyes or diseased spots removed (figs. 2 and 3), and the peeled potatoes weighed again. They were then sliced with a vegetable cutter into slices one-sixteenth of an inch thick; these slices were weighed (fig. 4) and put to soak in cold water, care being taken to keep each lot or variety in a separate pan. Each lot was washed in cold running water until the next lot had been weighed, peeled, sliced, and weighed again. It was then placed in a pan of cold water, while the second lot took its place under the faucet of running water (fig. 5). By the time the last lot had been prepared and placed under the faucet, the first lots had been soaking in cold water for several hours. The water in the pans was changed until the last wash waters were practically free of starch.

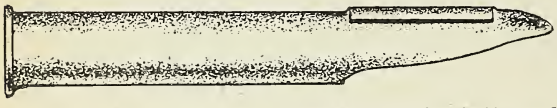

FIG. 3.—Small apple corer or vegetable peeling knife used to remove eyes and diseased spots from potatoes. There is a blade at the side, and if a mechanical peeler is not available knives of this description are better for peeling than ordinary paring knives.

The frying pan and oil were weighed before and after the chips were cooked, to determine just how much oil was used in making a given weight of chips. A thermometer was hung in the frying pan, the bulb being covered with oil, in order that uniform temperatures might be secured for each experiment. When the oil reached 210° C. (410° F.) the thermometer was removed to another pan of hot oil, the inner basket containing the raw sliced potatoes lowered into the hot fat (fig. 6), and the slices stirred constantly with a long-handled spoon. The slices were not dried, but as much of the water as possible was removed by shaking before lowering them into the hot fat. When the water on the potatoes had boiled away and the slices were crisp and golden brown, the frying basket was raised, the excess oil drained off, and the chips emptied on brown paper to dry (fig. 7). They were later weighed (fig. 8), sprinkled lightly with salt, and scored by the three judges.

HANDLING THE FAT IN MAKING CHIPS.

If the sliced potatoes are put into oil which is at a low temperature, they take a long time to fry and absorb so much grease that they are both soggy and unpalatable. Moreover, the more grease consumed in frying, the greater the expense of the product. The aim of the hot-water bath in Miss Farmer's[1] recipe was to coagulate the protein in the potatoes, thus searing the surface and making it impossible for much grease to soak in. The same result may be attained by heating the oil to a point just below smoking before the slices are put in. The higher the temperature that can be maintained, the sooner the surface of the potato will be crusted over and the less oil will penetrate. The water on the raw sliced potatoes and the temperature of the inner frying basket itself will lower the initial temperature of the

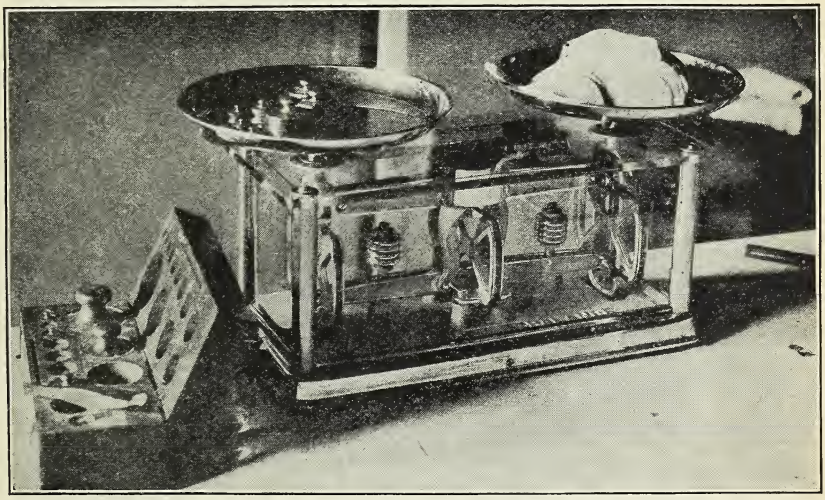

FIG. 4.—Weighing the slices of potatoes to determine the total loss in peeling and slicing.

oil, and it will take several minutes for the water to boil away and the fat to regain the heat it lost. Fats do not "boil." It is the water in the oil that makes it bubble when heated, and until this has been changed to steam and evaporated the temperature of the fat can not be raised much above 100° C. (212° F.). The hotter the initial temperature of the oil, the more quickly the water will be boiled away. As the water evaporates, the oil becomes still and the temperature increases rapidly. It should be reheated after each batch of chips is removed. The only certain laboratory method of determining the temperature of the fat is to suspend a thermometer in the center of the pan.

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[1] Farmer, Fannie Merritt. Op. cit.

Oil can not be used indefinitely without being renewed. After prolonged use of the oil the chips do not brown well and take too long to cook. Much foreign matter has been absorbed by the oil, which can not be removed by the most careful straining. It should be thrown away or used for soap grease. The common practice in potato-chip factories is to replace what is used up in the cooking process by adding fresh oil. This, however, should not be continued indefinitely, entirely fresh oil being required at least every few days. The most successful potato-chip factory which was visited makes a practice of renewing the oil every second or third day. The small particles of potato are skimmed out after every batch of chips is removed and all the oil carefully filtered each night after the close of business. New oil is added as needed during the day, and every sec-

FIG. 5.—Soaking the different lots of potatoes in pans of cold water preparatory to frying into chips. The last lot is still under the faucet of running water.

ond or third night the contents of the kettles are emptied and sold for soap grease. The result is a high-quality potato chip that will keep sweet for weeks. Some manufacturers make no effort to renew their oil entirely, simply adding fresh oil as needed. As a result the oil is never entirely sweet; and the old, worn-out oil which is always present affects the ease of cooking, the flavor, and the keeping quality of the chips.

In the refined cottonseed oil sold for cooking purposes there is remarkably little of the foreign matter from which the oil is expressed. Small particles of such foreign matter act as ferments if left in the oil and set free fatty acids which make the oil turn rancid and lower its smoking point. Chips can be cooked at a higher temperature in oil that is free from such impurities than in oil that has not been as highly refined. The small particles of fried potato or of the plant from which the oil is expressed burn and smoke at a comparatively low temperature and impart a scorched flavor to the oil, which is

transmitted to the chips. Hence the importance of buying high-grade oil and of carefully skimming out little particles of potatoes after each batch of chips is removed.

EQUIPMENT.

The mechanical peelers have been found very satisfactory as time, labor, and food savers. Of course, in the average household vegetables are not prepared in quantities large enough to make necessary the purchase of such equipment, but in restaurants, hotels, or large establishments they are found very serviceable. In potato-chip fac-

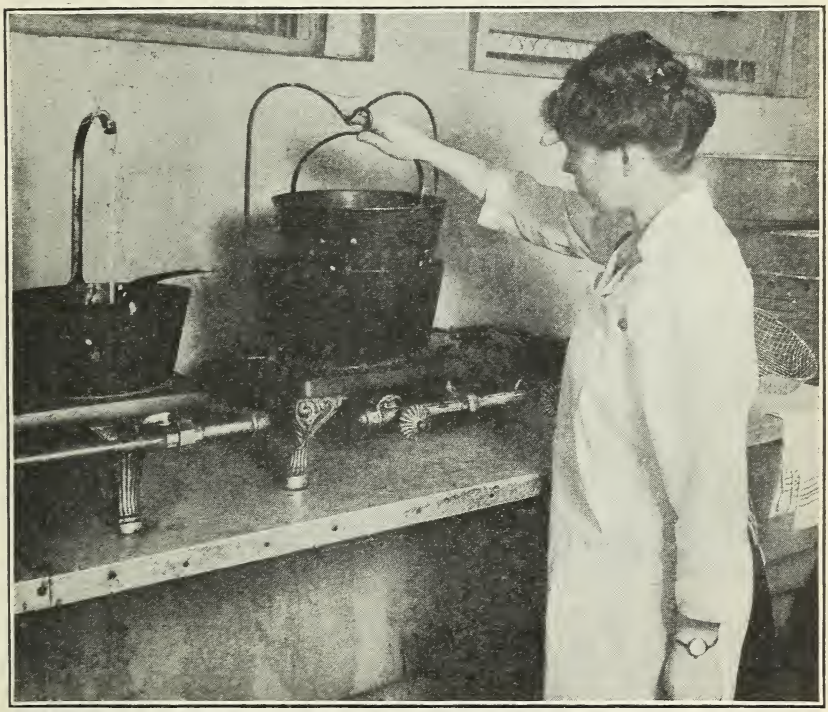

FIG. 6.—Lowering the inner basket full of raw sliced potatoes into the hot oil. The thermometer is now hung in the kettle at the left.

tories they are indispensable, and every chip factory has one or more large power machines. Figure 9 shows the small hand-power peeler which was used in the potato-chip experiments. Six or eight potatoes were peeled simultaneously. The loss in paring was less than by ordinary hand peeling, for the sharp edges of the carborundum lining nicked off the skin without cutting deeply into the flesh. The loss was least, of course, when the potatoes were smooth and regular, as the abrasion tended to wear down knobs and irregularities and leave the potatoes round or oval-oblong in shape. Deep eyes or bad spots had to be removed by hand, however. One of the small

apple corers and vegetable peeling knives retailing at 10 or 15 cents (figs. 2 and 3) was used for this purpose. In potato-chip factories a number of women or girls are employed to go over the potatoes as they are emptied from the peeler to cut out the eyes and imperfect places.

Some form of vegetable slicer is essential, as it is impossible to slice the potatoes thinly enough and evenly enough by hand. Satisfactory slicers may be obtained, either turned by hand power or motor driven. A small hand-power slicer used in 1914-15 did not prove satisfactory for laboratory tests, for the slices were thicker at

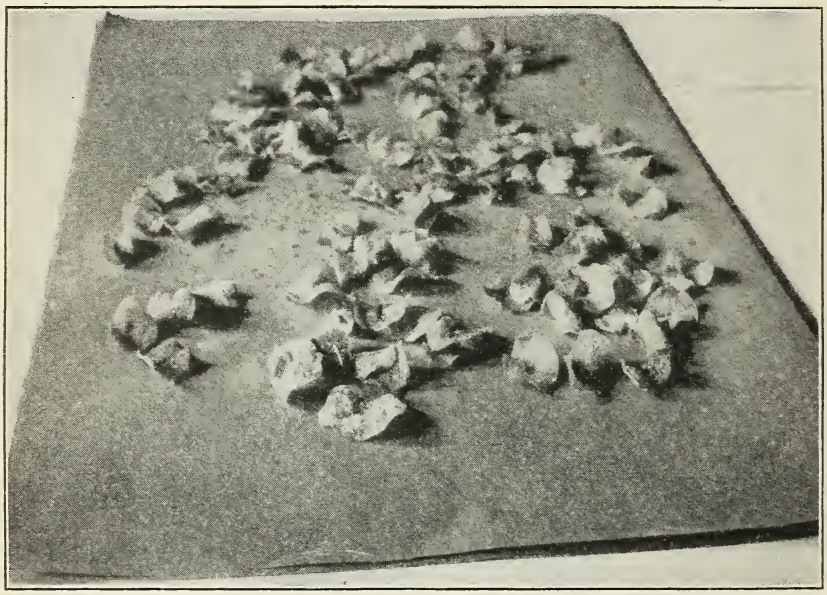

FIG. 7.—Draining the excess oil from the potato chips by spreading them on brown paper.

one side than the other, because of an imperfection in the casting of the knives. As it was necessary to secure uniformly even slices for experimental work, a larger slicer, also hand driven, was obtained at the beginning of the 1915–16 season (fig. 10). A number of large power-driven mechanical slicers, suitable for use in factories, are on the market.

When making chips at home the slices may be soaked in any kind of pans that are available. In factories they are generally soaked in tubs with fresh water fed in through rubber hose or in big tanks especially built for the purpose with fresh water flowing in at one end and an outlet pipe at the other end to carry off the wash water and starch. When working with large quantities it is generally found worth while to salvage the potato starch deposited by this wash water and by the waste from the potato peeler.

The best vessel in which to fry the chips is one that is deep rather than wide, with an inner perforated basket in which the chips can be lowered and raised. Steel friers in two parts, which are suitable for frying chips, croquettes, chicken, etc., can be obtained at hardware stores. Practically every family has some kettle suitable for deep-fat frying, and if necessary the inner basket can be improvised from steel wire. These frying pans should be of iron or steel, which is not affected by the highest cooking temperature. It is not safe to use tin or enamel-ware pans, which melt or chip off when very hot. Most potato-chip factories have large frying kettles built to suit their particular requirements, sometimes round, sometimes oblong in shape, and with special heating equipment for either gas or coal. Generally the kettles are built in one piece with the stoves. In some cases

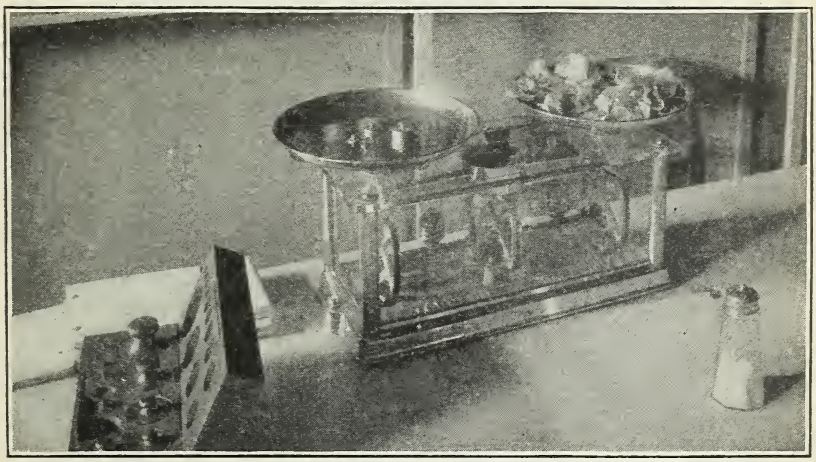

FIG. 8.—Weighing the chips, the last step before they are salted and judged.

inclined boards at one end on which the chips are emptied as skimmed out of the oil serve as drains to carry the surplus oil back into the tank or kettle. The sliced potatoes are lowered into the oil in heavy wire baskets made to fit the shape of the kettles. Sometimes, instead of frying baskets being used, the raw slices are emptied directly into the oil and the chips removed with perforated scoops or long-handled wire skimmers.

SELECTING POTATOES FOR CHIPS.

Not every potato will make a good chip, and the excellence of the finished product, here as elsewhere, depends on the materials used and the care exercised in their preparation. The following requirements should be observed when selecting potatoes for chips:

Use mature potatoes. New potatoes in the spring or early summer do not make good chips. They should not be used before the skin sets. Manu-

facturers who use potatoes in large quantities are agreed that the old stock is preferable for chips to the immature potatoes of the spring or early summer.

Use potatoes high in starch. A waxy or soggy potato does not make good chips. Select a variety that is known to be mealy when baked or boiled. The raw flesh should be firm and crisp when sliced with a sharp knife.

Use large or medium-sized round, smooth potatoes with shallow eyes. The size and shape do not affect the cooking quality, but they do influence the quantity and appearance of the chips. Round potatoes are better than long ones, as there is less waste in peeling, especially if a vegetable peeler is used. Deep eyes are objectionable, because of the difficulty of paring and the waste involved and because they make ragged-looking slices.

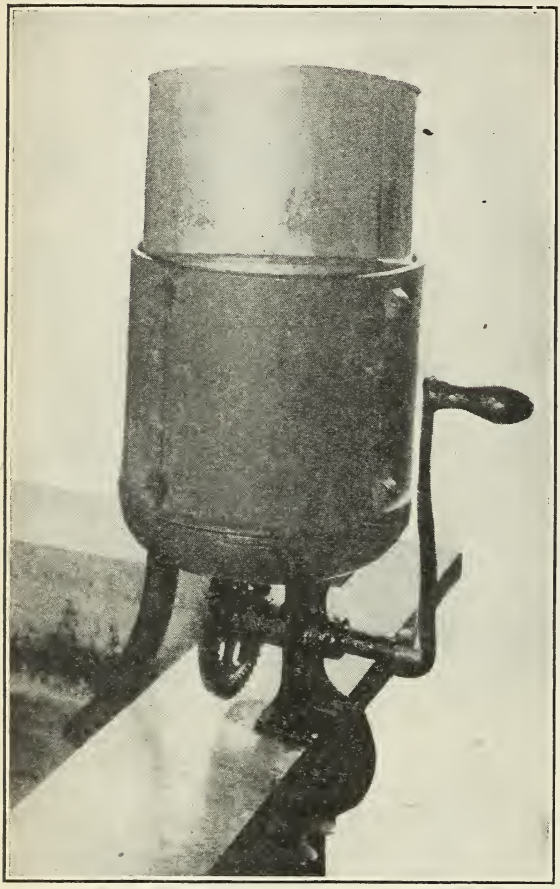

FIG. 9.—Small hand-power vegetable peeler. The potatoes are thrown by centrifugal motion against the carborundum lining, which nicks off the skin in small bits. Fresh water drips through the perforated pan at the top, carrying away the skins through the rubber waste pipe at the base.

Care should be taken not to cook too many chips at once. The fat should be deep enough to cover the slices completely, and allow them to lie flat and be crusted over quickly. If the kettle is too full, the water on the raw slices will bubble high and splash over the sides of the pan or vat. They cook quickly, the time required varying with the size of the kettle and the quantity of oil and potatoes used. Three to five minutes is a good average. If they take longer something is wrong; either the oil is not hot enough or the quantity of potatoes cooked is too great in proportion.

CAUSES OF FAILURE IN MAKING CHIPS.

The troubles of commercial manufacturers are generally due to one or more of the three following causes: (1) The use of a potato

variety not adapted for making into chips. (2) Improper washing of the sliced potatoes. Some factories do not recognize the importance of removing a maximum amount of starch. The result is a tough instead of a crisp chip. (3) Using the oil at too low a temperature and not renewing it frequently enough. When the oil is not hot enough the chips absorb too much grease, and when it is too old they have a burned or spoiled flavor and turn rancid quickly. Chips fried in fresh sweet oil should keep sweet for weeks unless

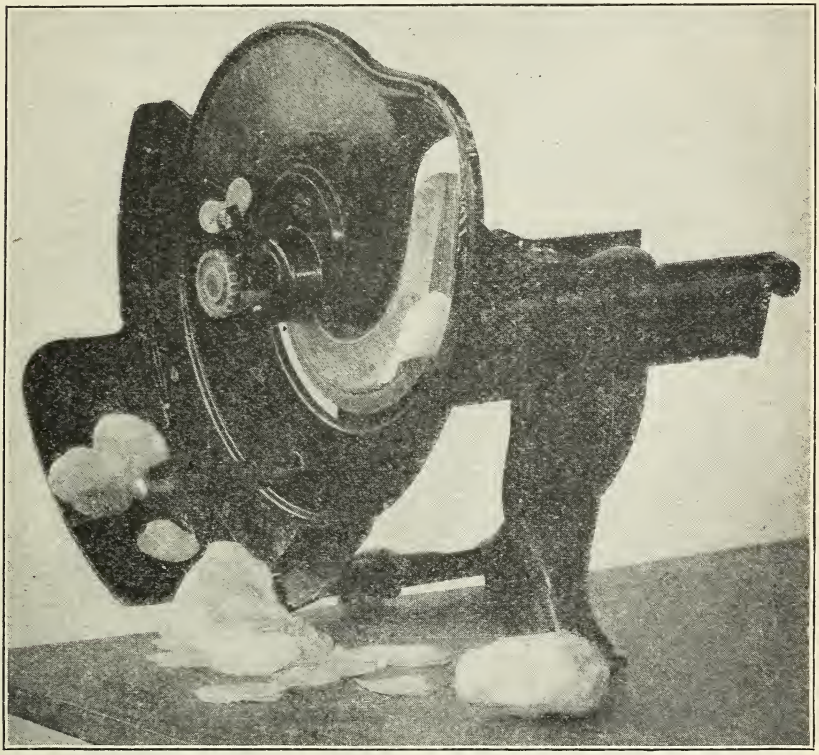

FIG. 10.—Hand-power vegetable slicer purchased at the beginning of the 1916 season.

subjected to very high temperatures and should permit long-distance shipment.

SCORE CARD USED IN THESE TESTS.

The form of the score card used in keeping a record of each lot of potato chips is shown here. The markings were all numerical, with the exception of the two subdivisions, "shape" and "desirability," under "tubers." Shape might be designated either by a descriptive term, such as flat, round, oval, etc., or by a pencil sketch. Symbolic markings, with the following divisions—very good, good, medium, poor, and very poor—indicated the desirability of each lot, as shown

by their general appearance and shape. The different weights of the tubers were recorded in grams. While the standard temperature of the fat was 210° C. and endeavor was made to raise the temperature of the oil to that point for each test, there were variations, especially when different frying media were being experimented with. Provision was made in one column, therefore, for keeping a record of the temperature at which each lot was cooked.

SCORE CARD USED IN POTATO-CHIP TESTS.

Variety.....Accession No.....

Grown at.....Picked.....Shipped.....

Stored.....in.....at.....Out.....

Test.....Potato chips. Frying medium.....Date.....

Tubers.			Weight.				Temperature of fat (° F.).	Cooking time (minutes).	Ease of cooking (10).	Appearance (5).	Crispness (5).	Flavor (10).	Total score (30).
Number.	Shape.	Desirability.	Unpeeled.	Peeled.	Sliced raw.	Chips.							

Method.....

.....

Remarks.....

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Ease of cooking was given 10 points out of a possible total score of 30, the rating being necessarily left to the judgment of the person who conducted the tests. It was based on the general behavior of the potatoes in the hot fat, the length of time a lot of given quantity took to fry, and the uniformity with which the slices colored and became crisp. The other three subdivisons of the score were marked by the three judges who tested all the potatoes. Under "Appearance" (5 points) the ideal was a clear, yellowish brown, flat chip. "Crispness" (5 points) was marked high when the chips were dry and crisp, greasiness or unevenness in cooking lowering the score. Flavor (5 points) was, of course, largely a matter of individual preference. With fresh bland oil there is no heavy, greasy flavor to obscure the variations in the different potatoes.

COMPARATIVE ADAPTABILITY OF VARIETIES FOR MAKING CHIPS.

The total scores given the different seedlings from which potato chips were made during 1915, 1916, and 1917, were averaged when several tests were made. S 22723 ranked highest, with an average

score of 28.4 for two seasons' tests, 27.2 in 1916 and 29.7 in 1917. In a 1-season test there was only one seedling whose total score exceeded 29.7, and that was S 38595 with 29.8, a difference so slight as to be negligible. Many of the seedlings graded 29.0 or more, however. The lowest average score was 20.9, given to S 7322, and the lowest single score was 12.3, given to S 1449. In this connection, it should be borne in mind that those potatoes which were evidently unsuited for chips were not subjected to this test.

TABLE 1.—*Comparison of the adaptability for chips of standard varieties of potatoes tested in 1915, 1916, and 1917.*

[Based on a score of 30 for perfect.]

Group and variety.	Score for making chips.			
	1915	1916	1917	Average.
Irish Cobbler:				
Irish Cobbler	24.1	23.5	27.2	24.9
Early Beauty	.....	.....	28.8	.....
Early Victor	.....	.....	28.2	.....
Flourball	.....	.....	29.5	.....
First Early	.....	.....	29.2	.....
New Early Standard	.....	.....	27.9	.....
Triumph:				
Triumph	19.2	.....	25.6	22.4
White Triumph	.....	.....	26.5	.....
Wood's Earliest	.....	.....	26.0	.....
Early Michigan:				
Early Michigan	.....	.....	28.0	.....
Early Albino	.....	.....	27.1	.....
Early Harvest	.....	.....	28.6	.....
Extra Early Sunlight	.....	.....	28.4	.....
Dewdrop	.....	.....	25.5	.....
Ehnola	.....	.....	28.3	.....
Early Rose:				
Early Rose	24.1	.....	.....	.....
Early Walters	.....	.....	24.2	.....
Northern King	28.2	27.6	27.9	.....
Woodbury's White Rose	.....	.....	27.3	.....
Early Manistee	26.4	27.0	26.7	.....
Spaulding No. 4 (Rose No. 4)	18.7	.....	.....	.....
Early Ohio:				
Early Ohio	18.8	25.4	27.1	23.7
Acme	.....	.....	26.7	.....
Early Dix	.....	.....	27.5	.....
Hebron:				
New White Hebron	.....	.....	27.5	.....
Burbank × Early Ohio	.....	.....	26.6	.....
Burbank:				
Viking No. 1	.....	.....	27.5	.....
Netted Gem	27.8	23.2	25.5	.....
Green Mountain:				
Green Mountain	24.2	26.6	29.0	26.6
Green Mountain, Jr.	.....	.....	26.5	.....
Carman No. 1	.....	.....	28.3	.....
Gold Coin	.....	.....	28.6	.....
McKinley	.....	.....	26.7	.....
Uncle Sam	.....	.....	27.4	.....
Wee McGregor	.....	.....	27.3	.....
American Wonder	.....	.....	29.5	.....
Longfellow	.....	.....	25.5	.....
Rural:				
Rural New Yorker	23.1	27.3	.....	25.2
Nonblight	.....	.....	26.3	.....
Pan American	.....	.....	28.6	.....
Sensation	.....	.....	26.3	.....
Sir Walter Raleigh	.....	.....	25.8	.....
Todd's Wonder	.....	.....	24.3	.....
Russet Rural	.....	.....	27.2	.....
Pearl:				
Pearl	22.2	.....	23.2	22.7
Dearborn	.....	.....	26.7	.....
Peoples	.....	25.5	.....	.....
Blue Victor	.....	.....	23.8	.....
Peachblow:				
White Peachblow	.....	25.3	26.1	25.7
McCormick	20.3	.....	.....	.....
White McCormick	.....	24.9	.....	.....
Up-to-Date:				
Factor	27.5	.....	.....	.....
Up-to-Date	25.8	25.1	26.3	25.7
Bull Moose	.....	.....	26.8	.....
Gold Standard	.....	.....	26.1	.....
Moreton	.....	.....	23.1	.....
Miscellaneous:				
British Queen	.....	.....	29.5	.....
Casseker Salathornchen	.....	23.0	.....	.....
Clio	.....	.....	24.8	.....
Country Gentleman	.....	.....	28.7	.....
Dalmeny Challenge	24.0	27.0	25.5	.....
Eldorado	.....	25.6	26.7	26.1
Garnet Chili	25.5	.....	26.1	25.8
Hamburger Eier	.....	25.1	26.8	25.9
Harvest King	.....	.....	28.7	.....
Jones Pink Eyed Seedling	.....	19.1	.....	.....
Keeper	.....	.....	26.0	.....
McIntyre	.....	25.6	23.6	24.6
Maggie Murphy	.....	.....	25.2	.....
New Era	.....	.....	27.2	.....
Pehuencha	.....	23.7	.....	.....
Prof. Maerker	.....	20.0	21.3	20.6
Perkin's Seedling	.....	.....	25.4	.....
Rural Blush	.....	20.3	24.7	22.5
Saxony	.....	.....	24.7	.....
Sport of Garnet Chili	.....	.....	25.1	.....
Switez	.....	7.0	17.8	12.4
Wohltmann	.....	10.1	24.2	17.1
Vitality	.....	.....	24.9	.....

Table 1 summarizes the scores of those standard varieties of potatoes which were made into chips. The Green Mountain received the

highest average score, 26.6, based on three years' tests. In the single season's scores there were three varieties that were tied for highest place, Flourball, American Wonder, and British Queen, all scoring 29.5 in 1917. The lowest average score, 12.4, was given to Switez, one of the German starch varieties. This variety was not adapted for chip making and was merely tried to see how it would behave. The same may be said of the potato receiving the second lowest score, 17.1, Wohltmann, another German variety. The lowest 1-year score was given to Switez in 1916 also.

LOSS IN PEELING AND QUANTITY OF CHIPS OBTAINED.

Table 2 gives a 3-year average of the loss in peeling and the quantity of chips made from all lots, with detailed figures for a few of the better known commercial varieties. The average waste in peeling all the potatoes handled during 1915, 1916, and 1917, a total weight of 233,492 grams, averaged 12.47 per cent, and the quantity of chips obtained averaged 29.85 per cent of the weight before peeling. In 1915 the average loss for all lots was 13.16 per cent and the average weight of the chips produced was 27.43 per cent of the original weight of potatoes. In 1916 the loss through peeling alone averaged 14.33 per cent; through both peeling and slicing, 17.48 per cent; and the quantity of chips produced averaged 30.22 per cent of the original weight. In 1917 the loss through peeling alone averaged 11.67 per cent; through peeling and slicing, 16.36 per cent; and the chips weighed 30.18 per cent of the original weight of potatoes. The 3-year average was therefore reduced by the 1915 figures, both the 1916 and the 1917 averages being slightly over 30 per cent. Commercial men figure on getting between 15 and 27 per cent of chips from each barrel or sack of potatoes. Their percentages of waste in peeling are higher than the 12.47 per cent given here, for more careful methods were employed in the laboratory than would be possible in a large factory. Langworthy [5] estimates the average waste in peeling potatoes to be 20 per cent, and with careless methods it may go even higher.

The lowest possible percentage of waste in peeling may depend upon a number of factors, such as variety, place where grown, and condition of the tubers (i. e., firmness, freedom from injury, decay, sprouts, etc.). The shape of the variety is one of the chief determining factors, for when the tuber is irregular, knobby, with deep or numerous eyes, it is practically impossible to prevent paring deeply. The skin itself varies slightly, being thicker on certain varieties, especially those with rough or netted exteriors. The influence of different soil types and environmental conditions sometimes causes a greater vari-

[5] Langworthy, C. F. Potatoes, sweet potatoes, and other starchy roots as food. U. S. Dept. Agr. Bul. 468, 29 p., 7 fig. 1917.

ation in shape, general appearance, and quality between specimens of the same variety grown in different parts of the country than is found in different varieties produced in the same locality. The condition of the tubers at the time of peeling also influences the percentage of waste. The value of careful handling, though less popularly appreciated in the case of potatoes than with most perishable crops, has been clearly demonstrated. Cuts and bruises caused by careless methods of harvesting and handling are followed by decay in storage and make necessary much deeper paring into the flesh. Old potatoes that have softened and begun to sprout are much more difficult to peel economically. When the flesh is hard and firm the knife can shave off a thinner portion of crisp flesh than after some of the water has evaporated and some of the starch has been converted into sugar, leaving the flesh with a rubbery texture.

TABLE 2.—*Comparison of certain standard varieties of potatoes, showing the loss in peeling and slicing and the quantity of chips produced, Arlington Experimental Farm, 1915, 1916, and 1917.*

Varieties compared.	Year.	Weight unpeeled (grams).	Average loss in weight (per cent).		Weight of chips per kilogram of potatoes (grams).		
			By peeling.	By peeling and slicing	Unpeeled.	Peeled.	Sliced raw.
Green Mountain	1915	1,000	12.2	.....	272	309.8	.....
	1916	4,417	16.8	21.46	289.1	347.5	368.2
	1917	6,377	12.70	17.09	305	362.2	376.5
2-year avearge, 1916 and 1917	.....	10,794	14.37	18.88	307.1	358.6	378.6
3-year average, 1915, 1916 and 1917	.....	11,794	14.10	.....	304.1	354.4	.....
Irish Cobbler	1915	2,002	13.49	.....	268.2	305.4	.....
	1916	2,192	19.84	21.99	264.6	330.1	339.2
	1917	396	19.95	22.72	275.2	343.8	356.2
2-year average, 1916 and 1917	.....	2,588	19.86	22.10	266.2	332.2	341.2
3-year average, 1915, 1916, and 1917	.....	4,590	17.08	.....	265.3	320.0	.....
Rural New Yorker	1915	2,000	14.35	.....	218.0	254.2	.....
	1916	2,581	9.26	12.55	275.1	303.1	314.5
2-year average, 1915 and 1916	.....	4,581	11.43	.....	250.1	282.4	.....
Early Ohio	1915	1,000	11.8	.....	321	363.9	.....
	1916	2,323	10.8	13.43	299.2	335.4	345.6
	1917	285	12.98	17.19	291.2	334.7	351.7
2-year average, 1916 and 1917	.....	2,608	11.04	13.84	298.3	335.3	346.2
3-year average, 1915, 1916 and 1917	.....	3,608	11.25	.....	304.6	343.2	.....
Up-to-Date	1915	1,005	9.25	.....	306.5	337.7	.....
	1916	2,008	5.8	8.87	325.7	345.9	357.4
	1917	395	6.83	11.39	308.9	331.5	347.6
2-year average, 1916 and 1917	.....	2,403	5.99	9.23	304.1	321.3	355.8
3-year average, 1915, 1916 and 1917	.....	3,408	6,95	.....	318.0	340.9	.....
Peachblow	1916	2,667	8.73	11.18	329.6	361.1	371.08
	1917	374	7.22	11.50	334.2	360.2	377.6
2-year average, 1916 and 1917	.....	3,041	8.54	11.21	330.1	361.0	371.8

TABLE 2.—*Comparison of certain standard varieties of potatoes, showing the loss in peeling and slicing and the quantity of chips produced, Arlington Experimental Farm, 1915, 1916, and 1917*—Continued.

Varieties compared.	Year.	Weight unpeeled (grams).	Average loss in weight (per cent).		Weight of chips per kilogram of potatoes (grams).		
			By peeling.	By peeling and slicing.	Unpeeled.	Peeled.	Sliced raw.
Netted Gem (Colo.)	1916	1,586	9.98	12.42	319.0	354.36	365.4
Netted Gem (Me.)	1917	264	12.5	16.66	306.8	350.6	368.2
2-year average, 1916 and 1917		1,850	10.32	13.02	317.2	353.8	364.8
Garnet Chili	1915	1,000	14.8	.....	277	325.1	.....
	1917	492	13.6	17.2	315	364.7	380.8
2-year average, 1915 and 1917		1,492	14.41	.....	289.6	338.2	.....
Pearl	1915	1,000	12.5	.....	234.0	267.4	.....
	1917	373	16.08	22.0	262.7	313.1	336.8
2-year average, 1915 and 1917		1,373	13.47	.....	241.8	279.4	.....
Bliss Triumph	1915	1,000	14.0	.....	197.0	229.1	.....
	1917	370	14.32	18.9	297.3	347.0	366.7
2-year average, 1915 and 1917		1,370	14.08	.....	224.0	260.8	.....
Early Manistee	1916	994	18.41	20.32	308.9	378.6	387.6
	1917	321	7.16	9.97	314.6	338.9	349.5
2-year average, 1916 and 1917		1,315	15.66	17.79	310.2	367.9	377.4
Eldorado	1916	1,000	14.2	17.5	319.0	371.8	386.7
	1917	210	10.00	16.19	304.7	338.6	363.6
2-year average, 1916 and 1917		1,210	13.47	19.96	316.5	365.8	382.6
Rural Blush	1916	432	33.8	36.34	240.7	363.7	378.2
	1917	297	12.45	16.83	285.0	353.8	372.4
2-year average, 1916 and 1917		729	25.10	28.39	268.8	358.8	375.3
McIntyre	1916	387	16.79	18.34	320.5	385.1	392.4
	1917	298	16.10	21.81	268.4	320.0	343.3
2-year average, 1916 and 1917		685	16.49	19.85	297.8	356.6	378.8
Hamburger Eier	1916	196	16.83	20.41	295.9	355.8	371.8
	1917	252	13.89	22.62	277.8	322.5	359.0
2-year average, 1916 and 1917		448	15.17	21.65	285.7	336.8	364.3
1-year average of all seedlings and varieties	1915	24,695	13.16	.....	274.3	310.8	.....
	1916	130,764	14.33	17.48	502.2	349.2	363.1
	1917	78,033	11.67	16.36	301.7	341.9	361.6
2-year average, 1916 and 1917		208,797	12.39	16.56	301.9	343.4	361.2
3-year average, 1915, 1916, and 1917		233,492	12.47	.....	298.5	341.0	.....

When the potatoes are sound and in good condition most of the 12.47 per cent waste in peeling is composed of flesh around the eyes. If the eyes are deep it is not possible to gouge them out with a knife as carefully as the skin is removed by the peeler. This loss is less important than an equally deep peeling elsewhere, however, for the internal medulla extends a branch to each eye, lessening the proportion of dry matter to water and reducing accordingly the food value of the flesh. East[6] has shown that the quality of the potato varies

[6] East, Edward M. A study of the factors influencing the improvement of the potato. Ill. Agr. Exp. Sta. Bul. 127, p. 375–456, 10 fig. Bibliography, p. 450–456. 1908.

inversely with the number of eyes, and that there is great variation within the variety.

Table 3 shows that approximately half a pound of oil was used for every pound of chips produced, or, to be more exact, 0.451 pound in 1916 and 0.434 pound in 1917. This was slightly less than the estimates furnished by two manufacturers of potato chips. Not all of this oil went into the chips, however, a great deal being lost through spattering over the pan, in draining the chips, and in straining the oil.

TABLE 3.—*Ratio of cottonseed oil required for making potato chips, tests of 1916 and 1917.*

Year.	Number of tests.	Average weight (grams).		Ratio.	
		Oil used.	Chips made.	Oil.	Chips.
1916	47	369	818	0.451	1
1917	33	312.45	718.66	.434	1

SUMMARY.

Potatoes are a universal article of diet, and their home manufacture into potato chips is entirely feasible. High-grade cottonseed oil heated to approximately 210° C. (400° F.) is the best fat in which to fry them. Vegetable oils or compounds are more satisfactory than animal fats, and liquids are somewhat preferable to the semiplastic compounds. No fat with a smoking point of less than 220° C. (428° F.) is satisfactory. The oil should be entirely renewed every second or third day when chips are manufactured in commercial quantities.

Mechanical peelers are necessary for commercial production and of great assistance in home manufacture. Vegetable slicers are essential for uniform results, as it is impossible to cut potatoes thinly and evenly enough by hand.

The best vessel in which to fry the chips is one that is deep rather than wide, made of iron or steel, with an inner perforated basket in which the chips can be lowered and raised.

Use mature potatoes, high in starch. Large or medium-sized, round potatoes with shallow eyes are preferable. The slices should be thoroughly washed in cold water and a maximum of starch removed.

In the experimental tests of the Bureau of Plant Industry, potato chips were scored on a basis of 30 points, distributed as follows: Ease of cooking, 10; appearance, 5; crispness, 5; flavor, 10.

The average waste in peeling all potatoes handled during 1915, 1916, and 1917 was 12.47 per cent, and the quantity of chips produced averaged 29.85 per cent of the weight before peeling. Commercial men figure on getting between 15 and 27 per cent of chips from each barrel or sack of potatoes.

Approximately half a pound of oil was used for every pound of chips produced.

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